SEP 22 1920

Biological & Medical Serials

May 1920. | Entomological Series. | Vol. V, No. 5.

Memoirs of the Department of Agriculture in India

THE RICE LEAF-HOPPERS (*NEPHOTETTIX BIPUNCTATUS* FABR., AND *NEPHOTETTIX APICALIS* MOTSCH)

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BY

C. S. MISRA, B.A.

First Assistant to the Imperial Entomologist

DIEU ET MON DROIT

AGRICULTURAL RESEARCH INSTITUTE, PUSA

PRINTED AND PUBLISHED FOR

THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA

BY

THACKER, SPINK & CO., CALCUTTA

W. THACKER & CO., 2, CREED LANE, LONDON

Price, Re. 1-8-0 or 3s.

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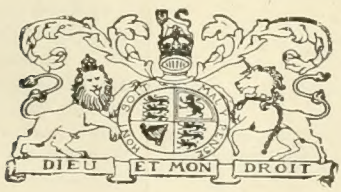

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NEPHOTETTIX BIPUNCTATUS.

Explanation of Plate XX.

Fig.	1.	Rice plant with young and adult hoppers on it.	
Fig.	2.	Eggs in a sheathing-leaf of a plant ..	×14
Fig.	3.	An egg (much enlarged)	
Fig.	4.	Nymph, 1st Instar	×72
Fig.	5.	Male hopper	×15
Fig.	6.	Female hopper	×15

EXPLANATION OF PLATE XX.

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Fig. 6. Female hopper .. .. .. ×15

THE RICE LEAF-HOPPERS (*NEPHOTETTIX BIPUNCTATUS* FABR., AND *NEPHOTETTIX APICALIS* MOTSCH).

BY

C. S. MISRA, B.A.,

First Assistant to the Imperial Entomologist.

[Received for publication on 19th June, 1919.]

Occurrence, damage and area affected.

The rice leaf-hoppers were reported for the first time damaging rice in the Sambhalpur District in the Province of Bihar and Orissa in 1910. But the hoppers appeared late in the season and consequently no notice was taken. During 1913 they again appeared although late in the season and did some damage to the standing crop of rice. The same year they were also reported from Champhai in the Lushai Hills .... Mr. J. Hezlett, I.C.S., Superintendent, Lushai Hills, Aijal, wrote on the 4th December, 1913 :—

* * * * * * * * *

"The flat areas under wet rice cultivation are small and are surrounded by miles of jungle. The insect is well known to the Lushais and frequently does some damage, but for the first time this year the damage done by it has become serious."

In the Chhattisgarh Division of the Central Provinces the pests were noticed for the first time in 1913, in which year they appeared late in the season and did some damage to the standing crop of rice. The following year (1914) they appeared early and over a much larger area. The damage was specially great in the Sakti State, and the Mungeli and the Janjgir Tahsils in the Bilaspur District and in Baloda-Bazar and Raipur Tahsils in the Raipur District in the Central Provinces. The damage done by the hoppers was so serious that the Commissioner of the Chhattisgarh Division, Mr. H. M. Laurie, I.C.S., Central Provinces, wrote :—

"I have been touring in the Mungeli Tahsil of the Bilaspur District and I find much complaint of havoc caused in respect to the heavier kinds of rice by the insect '*Mahor*' or '*Maho*' concerning which you have already made some inquiries. The Deputy Commissioner does not think that the damage in the Mungeli Tahsil has in any village exceeded four annas, but I am not

quite sure about this. I am inclined to think that in some villages where '*Mai*' or '*Garhuna*' *dhan* constituted the bulk of the rice sown the damage may have arisen to eight annas or in some cases even more. A loss of four or six annas in this kind of *dhan* will, according to my belief, be found to be a matter of fairly common occurrence even in the Mungeli Tahsil. The damage done in the Janjgir Tahsil is said to be greater than in Mungeli. There is complete unanimity of opinion that the pest is absolutely new in the experience of the Chhattisgarh cultivators. Not even the oldest inhabitant has seen anything like it before . . . . ."

In order to understand the damage done by the hoppers in the Chhattisgarh Division in the Central Provinces one had to visit the worst infested areas. In such places the condition of the cultivators, as well as the cattle, was pitiable. The crop was left standing in the fields and was not harvested. There was not only scarcity of grain but the cattle had not enough straw to eat. By the attack of the hoppers the straw was rendered insipid, and, as such, was not liked by the cattle. Further, with the thick deposition of honey-dew on the rice leaves the straw had become sticky, and smelt mouldy. It was thus feared that if the pests broke out again in the ensuing year (1915), the state of affairs would be very grave indeed. In this connection Mr. D. Clouston, Deputy Director of Agriculture, Southern and Eastern Circles, Central Provinces, wrote on the 16th June, 1915 :—

" It appears to me, however, that in the event of the pest doing as much damage this year as it did last year, it would be highly advisable to consider whether it is not necessary to appoint a larger entomological staff for the pioneer work. Even if the pest should fail to spread beyond the confines of Chhattisgarh, we still have in that division alone nearly 3 million acres of rice. If we allow only 10 per cent of the area being affected, we would still have 300,000 acres to deal with . . . ."

The total area under rice in the Chhattisgarh Division, Central Provinces, is :—

	Acres
Drug District	679,786[1]
Raipur District	1,486 115
Bilaspur District	1,149,583
TOTAL ...	3,315,484

Calculating a loss of six annas in the rupee (*vide* the Commissioner's report quoted above) for the badly infested sub-divisions (*Tahsils*) of the Raipur and the Bilaspur districts :—

[1] *Season and Crop Report, C. P. & Berar*, 1915-16,

Bilaspur District.[1]

		Acres		Total
Janjgir	... ...	566.326		
Bilaspur	... ...	329.167		
Mungeli	... ...	144.655		
		1,040,148	...	1,040.148

Raipur District.

Mahasamund	... .	484,928		
Baloda-Bazar	... ...	358,181		
		843,109	...	843,109
		TOTAL	...	1,883,257

the total loss approximates 14½ million rupees on the basis of 548 lb. cleaned rice per acre[2] at Rs. 3-1-0 the whole-sale price of common cleaned rice at Bilaspur (Feb. 15, 1916).[3] This enormous loss represents the destructiveness of the hoppers for one season only and it is not known what would have been the accumulated loss, had they run for a series of years consecutively.

During 1915 the pests appeared late and in small numbers and in consequence no serious damage was done. But previous to their appearance, the small white leaf-hoppers—*Sogata pusana* Dist., *Sogata distincta* Dist. and *Sogata pallescens* Dist.—(Figs. 1, 2 and 3)—appeared in enormous numbers

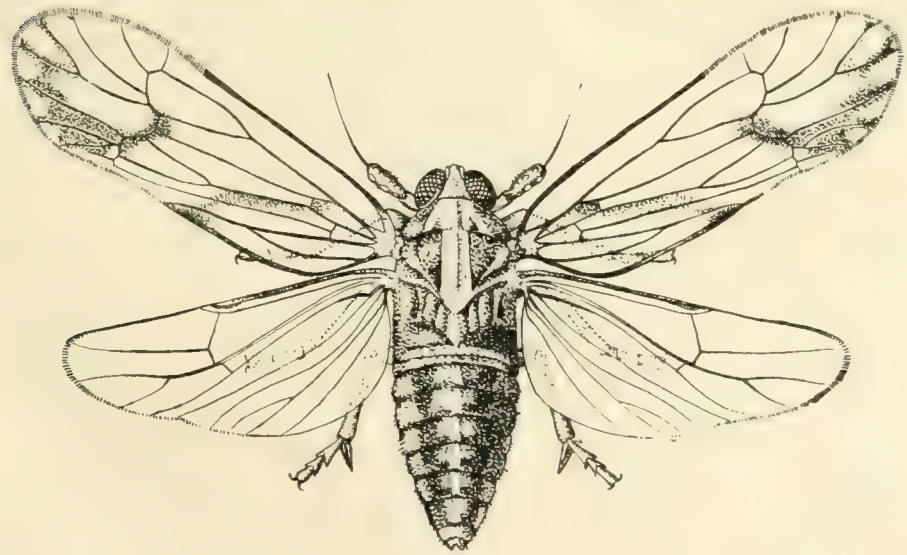


FIG. 1. *Sogata pusana.* (× 20).

[1] *District Gazetteers, Raipur & Bilaspur*, 1907-08.
[2] *District Gazetteer, Drug*, 1907-08.
[3] *Season and Crop Report, Central Provinces & Berar*, 1915-16.

along with the rice grass-hopper (*Hieroglyphus banian*) at the end of July and the beginning of August and it was feared that this time too the rice crop would be damaged seriously. In fact, in most places complaints were made that the *Maho* (*N. bipunctatus* and *N. apicalis*) had appeared and had begun damaging the rice plants. In others, the white leaf-hoppers were actually mistaken for the *Maho* and the measures recommended to check them were adopted against the white leaf-hoppers. No doubt the damage done by the white leaf-hoppers (*Sogata* spp.) was very much akin to the damage done by the *Maho* (local name for the leaf-hoppers *N. bipunctatus* and *N. apicalis*). Both live by sucking the juice of the tender plants and the grain in the ears and both exude a sticky substance, technically known as honey-dew, which, falling on the leaves, leads to the growth of a black fungus *Capnodium* sp. If both the pests are present concurrently, the young plants wither and the infested fields present a blighted appearance. Continuous rain is favourable

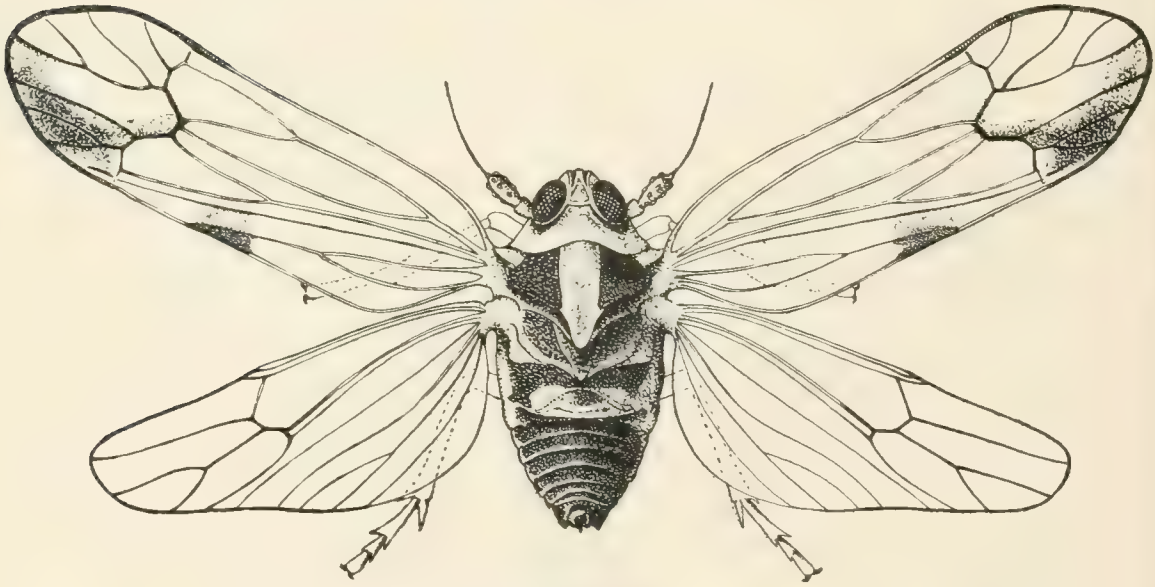


FIG. 2. *Sogata distincta.* (× 24).

to the development of the white leaf-hoppers and not so favourable to the development of the *Maho*, and as there were heavy rains at the end of July and the beginning of August 1915, it was feared that the two pests would again ruin the crop completely. But with the break in the rains in the middle of September, the white leaf-hoppers perished and no more trouble was

experienced. Numbers of young leaf-hoppers were parasitized by a Dryinid, and it was a common sight in the infested fields to see them hopping about from plant to plant with broad, oval, blackish sacs on their abdomen laterally. A week or ten days after, the leaves were seen covered with the whitish hammock-like pupa cases of the Dryinid. Even the few adult Dryinids that had emerged were to be seen flitting about the infested plants. By the third week in September the whitish leaf-hoppers as well as the rice grass-hoppers (*H. banian*) had disappeared and the *Maho* was reported to have appeared in a few villages in the Sakti State in the Bilaspur District. No doubt reports used to come in intimating the appearance of the *Maho* in the various parts

FIG. 3. *Sogata pallescens.* (× 20).

of the division, but on close examination in the third week of October 1915, it was found that, though the leaf-hoppers were there, they were present in small numbers only and could not damage the crop seriously. In many places, the cultivators, apprehending the possible appearance of the leaf-hoppers, had sown their fields with *Harhuna*—early ripening varieties of rice—and by the time the leaf-hoppers appeared by the middle of October 1915, the plants had matured and were past damage. The leaf-hoppers did not appear at all during 1916 and 1917, and no reports of their appearance have been received up to the time of writing this Memoir

Besides the Central Provinces, the hoppers have also been reported bad from Sambhalpur during 1910, 1912, 1914 and present in small numbers only during 1911–1913 and 1915. Just as in the neighbouring district of Bilaspur the damage done by the leaf-hoppers during 1914 was very widespread and serious and in June 1915, when I visited the district in connection with the leaf-hoppers, the cultivators were very apprehensive of any subsequent outbreak of the pests and were willing to adopt any measures that were found effective against them. They have also been reported from Kendrapara in the Cuttack District, and Balasore. The damage in the latter district was also very great and widespread, and Mr. F. M. Howlett, the Pathological Entomologist, who visited the area in 1914, wrote :—

"It was seen that in some fields practically the whole crop was destroyed, the plants withered and discoloured. These seemed to be all late-transplanted, the earlier crops having suffered much less, often hardly at all. A rough estimate gives 25–40 per cent as the average amount of damage in Balasore and its immediate neighbourhood. Jassids (Genus *Nephotettix*) were considered by the cultivators to be responsible for the whole damage. They were present in large numbers and in all stages."

The hoppers have also been reported from Ranchi and Champhai in the Lushai Hills.

The appearance of the infested fields.

The infested fields appear blighted. If the pests appear early when the plants are only two months old, the latter at first turn pale-yellow and soon after wither. If the pests appear late the apical buds of the plants remain somewhat swollen and the ear-heads fail to come out. If, however, the pests appear when the ears have come out and grain is being formed they turn pale-brown and later on russet-brown without any grain in them. The leaves, specially the lower ones, become thickly covered with a layer of honey-dew exuded by the nymphs as well as by the adults. In some places, specially in Janjgir Tahsil and the Sakti State, complaints were made that the water of the infested fields had turned red and that when such fields were harvested a thick layer of red was found deposited on their surface. I examined this aspect of the hoppers' attack but was unable to find any data to support the belief. It is possible that, when the infested fields were about to be harvested, occasional rain fell and it washed the lateritic nodules in process of disintegration on the *bhata* soils—so common in the Chhattisgarh Division, Central Provinces—and the washings from these accumulated in the low-lying fields below the *bhata* lands. When the water from such fields evaporated, a thin

layer of reddish sediment was naturally deposited on the surface soil of fields. Besides this plausible explanation of the phenomenon witnessed by the local cultivators, I could not offer any. I examined the water of the worst infested fields during 1915 at Janjgir but could find no connection between the presence of honey-dew on the leaves and the reddish discoloration of the infested fields.

Life-history.

In the Chhattisgarh Division of the Central Provinces the pests are called '*Maho*' or '*Mahor*,' but the former term is generally more in use. Prior to 1913 in the Central Provinces and 1910 in Sambhalpur in the Province of Bihar and Orissa, nothing was known about the hoppers. Till then they were known as the "Green-flies" of cities like Calcutta, where they swarm in thousands around the electric lamps in the streets as well as the bare lights in houses. It is an instance of an insect which is considered harmless at one time, but suddenly comes into prominence, does considerable damage for a series of years and again sinks into insignificance. The hoppers were very bad in 1914. They did slight damage in 1910, 1913 and 1915, but did not appear in 1916–17 and the current year. The causes which have contributed to their disappearance directly or indirectly are not well understood up to this day. That this has been brought about by the agency of the parasites is out of the question, as very few effective parasites were found either on the eggs, the nymphs or the adults.

After the winter is over, the hoppers begin to breed in succulent grasses in tank beds and such other places which contain green grasses. Until the beginning of June they remain breeding in succulent grasses as well as nursery seed-beds. From these they move on to the tender rice seedlings in the beginning of July and, if the rains are heavy and continuous, the majority of them are washed away and there are no reports about the *Maho* from any part of the ordinarily infested areas. If, however, the rains are not very heavy in July and August and there is a spell of fair weather, then the hoppers breed very fast and overrun large tracts of rice lands. At least some such state of affairs could be deduced from close observations made in the affected areas during 1914–1916. In some years they appear late in October or early in November and very little damage is done, as by that time the early-ripening varieties of rice are ready to be harvested. If, however, any damage is done, it is to the late-ripening transplanted varieties of rice. When such is the case, vast hordes of hoppers are destroyed annually in the small lamps that are lit up in the towns and villages on the *Dewali* day—a Hindu festival which occurs yearly in the end of October or the beginning of November. The

adult hibernates in grasses, but only in small numbers. Of the two species of hoppers, *Nephotettix bipunctatus* Fabr., and *Nephotettix apicalis* Motsch., commonly known as the *Maho*, the former preponderates over the latter, as was evident from counts made in the fields at Janjgir (Bilaspur), Sindewahi (Chanda), and Pusa (Bihar) during 1914 and 1915.

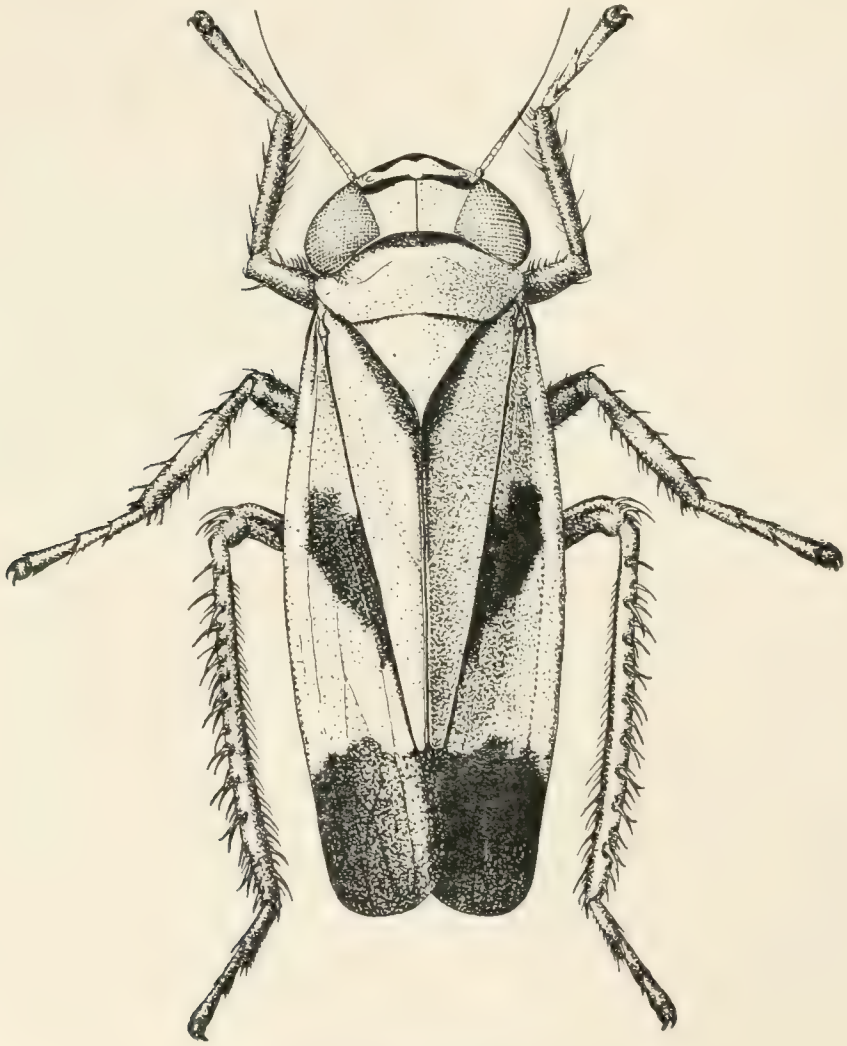


FIG. 4. *Nephotettix apicalis.* (× 24).

The hoppere are small, greenish insects which jump about from plant to plant and suck the juice. The adults come to light freely and are very active.

The young ones do not fly so actively as the adults and are not attracted to light. The males have two prominent black spots on their bodies, the females have no such markings. In order to be able to distinguish between the two species, both of which are designated as the *Maho* by the local cultivators, the following descriptions of the two species from the *Fauna of British India*, Vol. IV, pp. 359–362, will enable one to distinguish one species from the other.

Nephotettix bipunctatus Fabr.

(Plate XX, fig. 5.)

Yellowish-green, shining, smooth face (except the lateral margins), and a spot on each side of clypeus black; tegmina with a spot before the middle and the apical two-fifths black; lateral spots to sternum and abdomen black. The female is usually without the discal black spot to the tegmina and with the face as just described for the varietal male.

Nephotettix apicalis Motsch.

(Text fig. 4.)

Yellowish-virescent, smooth, shining face, anterior sub-impressed line on vertex between anterior margins of eyes, anterior margin of pronotum, scutellar and commisural margins of clavus, a spot before the middle extending to the claval suture and there acutely produced hindward, the apical third to tegmina, sternum, abdomen, greater part of the femora, anterior tibiæ and tarsi black; the posterior tibiæ at the bases of the spinules spotted with black; ventral incissure flavescent.

Closely allied to *N. bipunctatus* Fabr., but differs in having the head shorter and more obtuse, anteriorly obtusely rounded and by the marking of same. Head as broad as pronotum but somewhat shorter, vertex a little longer in the middle than at the eyes, scarcely twice as broad between eyes as long, anteriorly within the margin transversely impressed.

In plain language, the females in both the species are unspotted. They are pale-green in colour, with a strong, brownish ovipositor with which they lacerate the tissues of the plant and deposit the eggs. The males, in both the species, are black; one has two black prominent spots on the wings, in the other there are two oblique black lines. There is very little difference between the females of the two species. In fact, the colour differences are so slight that none but a trained man could differentiate between the two species. The adults, both males and females, remain on the lower surface of leaves mostly near the midribs sucking the juice during the hottest part of the day. At dusk they become active and fly from plant to plant. While feeding they exude a sticky liquid, called honey-dew, which, falling on the leaves below, makes them very sticky. In the worst infested localities from 37 to as many as 127, and even 167 adults and nymphs have been counted feeding on a single leaf of a plant. The drain caused by such a horde of insects becomes apparent very soon as the plant withers and dies prematurely.

The Eggs.

The female (Plate XX, fig. 6) lacerates the tissues of the bases of sheathing leaves with her strong ovipositor and deposits the eggs in a mass in a line touching each other closely. The majority of the eggs were found laid at the base of sheathing leaves although in the worst-infested fields eggs were also found laid in the edges and midribs of leaves. At the bases of sheathing leaves, the place where the eggs are laid swells up and turns slightly pale-yellow. On the same leaf there may be as many as six to seven egg clusters but in the majority of cases the number varies from two to four. The effect of prolific oviposition is that the sap which should have gone up for the development of the leaves is cut off, and in consequence they turn pale-yellow and appear sickly.

The female begins to lay eggs the tenth day after reaching maturity. She is easily distinguished from the male by the absence of black spots on the wings and by the presence of a strong ovipositor (Plate XX, fig. 6). When about to lay eggs she moves about the leaves and having selected the place—which, in the majority of cases, is the base of sheathing leaves to stems—she settles down, stretches out the legs, and with the ovipositor makes a longitudinal slit separating the upper from the lower epidermis, and inserts the eggs. In one particular instance on 21st October, 1916, a female was observed to lay 34 eggs within an hour. After the eggs are laid she shakes the wings briskly and moves away. Externally there is no sign of the eggs, except that there is some swelling on the spot if looked at closely. In some varieties of paddy with deep green leaves, the places of oviposition turn pale-yellow. The length of the slit containing the eggs varies from 6–9 mm. In some cases the eggs were found laid on both the edges of the leaves.

The number of eggs laid by a female varies from 24 to 34, though in some egg-masses the number of eggs laid was as low as 18 and as high as 37.

1st Egg mass	...	...	22	
2nd ,, ,,	...	...	24	
3rd ,, ,,	...	...	18	
4th ,, ,,	...	...	24	
5th ,, ,,	...	...	20	
6th ,, ,,	...	...	21	
7th ,, ,,	...	...	24	
8th ,, ,,	...	...	35	
9th ,, ,,	...	...	37	Average No. 24.

Each egg is 1·35 mm. long and about 0·30 mm. broad in the middle. It is smooth, rounded at both ends. Each egg touches the next one laterally and is somewhat rounded in the middle. When laid, the colour of the eggs is pale-yellow. Later on they turn pale-yellow with two bright pinkish spots

representing the eyes of the nymph within. As the nymph develops within, the two spots turn deep maroon in colour (Plate XX, figs. 2 and 3).

When the nymph emerges, a slit opens at the apex represented by two deep maroon coloured specks and the head is thrust out. The nymph then moves from side to side until it is clear of the egg-shell. It is then slimy and remains enveloped in a thin membrane, which on exposure ruptures, and the nymph is able to come out leaving the amnion attached to the apex of the empty egg-shell as a thin, crumpled pellicle. In some cases the crumpled pellicle lies on the leaf close by the opening in the egg-shell. At times when nymphs are emerging in numbers they may be seen standing bolt upright against the leaf surface. They are able to remain in this position as their bodies are moist whilst enveloped in the thin membrane containing them.

The eggs are parasitized by a small pale-yellow Chalcidid. The parasitized eggs turn black and the Chalcidid emerges by making a small, clean circular hole on the egg. After the emergence of the parasites the empty egg-shells appear deep fuscous brown with their apices black. But the number of parasitized eggs is not very large, and this parasite is not effective in checking the increase of the hoppers.

The Nymphs.

The nymph on coming out of the egg-shell is active and after a few seconds only begins to move about on the leaf (Plate XX, fig. 4). As soon as it comes upon a succulent spot it begins sucking the juice and exuding the honey-dew which falls thickly on the lower leaves. It is on account of this that the leaves become sticky and are covered with a black fungus. Locally the cultivators explained the discoloration of water of the infested fields by the exudation of honey-dew, but on close observation there appeared to be no connection between the discoloration of water of the infested fields and the falling of the honey-dew. The discoloration of the infested fields is probably due to the accumulation of washings from the *bhata* soils which are covered with lateritic nodules in process of slow disintegration.

The nymphs with the adults drain the sap of the plants which in consequence become pale and subsequently wither away without putting forth ears. If a heavily infested leaf be held up to the light it will be found to contain a large number of tiny transparent holes representing the punctures made by the nymphs as well as the adult hoppers with their strong beaks. The nymphs do not fly, but when disturbed, jump from plant to plant. They remain feeding below leaves during the hottest part of the day. Unlike the

adults they are not attracted to light. In the case of the worst infested fields as many as 167 adults and nymphs were found on a single leaf.

The nymph after coming out of the egg-shell is pale-yellow with prominent deep maroon eyes, the thorax and the abdomen are dorso-laterally suffused with faint ochreous. The legs are whitish. Antennæ dull white (Plate XX, fig. 4). The nymphs of the early instars remain feeding and exuding the honey-dew on the lower surface of leaves. When about to moult, the legs are thrown wide apart and a slit opens dorso-frontally and the nymph comes out. The rostrum is embedded so firmly in the tissues of the leaf that if the exuvium be removed with a teaser a part of the body breaks off leaving the head with the sheaths to rostral setæ embedded in the tissues of the leaf. When full-fed the nymph becomes very active and may then be seen moving actively up and down the leaves. With the least disturbance they jump off from plant to plant and remain feeding quietly on the lower surface of leaves during the hottest part of the day. They are then 4·38 mm. long, 1·24 mm. broad, the head is pointed anteriorly ; general colour pale green with prominent maroon coloured eyes. The apex of the tegminal pads reaches the middle of the third abdominal segment dorsally. Anterior and intermediate tibiæ spined lightly, the posterior tibia spined thickly. Abdomen broad at base, tapering posteriorly. The first abdominal segment has no spines on it dorsally. There is a series of deep, brown spots situated dorso-transversely on the middle of the second to the seventh abdominal segments, followed by a series of four deep ochraceous-brown setæ inclined posteriorly on the second to the fifth abdominal segments. On the sixth and the seventh abdominal segments there are six such setæ dorsally, on the eighth abdominal segment seven, and on the anal end there are only four such setæ.

The nymphs before maturing into adults pass through five moults.

Eggs laid	Eggs hatched	First moult	Second moult	Third moult	Fourth moult	Fifth moult
3. IX. 16	7. IX. 16	11. IX. 16	14 IX. 16	16. IX. 16	18. IX. 16	20. IX. 16 Adult emerged
21. X. 16	25. X. 16	28. X. 16	31. X. 16	2. XI. 16	6-8. XI. 16	13-15-XI. 16 Adult emerged

When about to moult the nymph becomes stationary on the leaf, the legs are thrown wide apart and it remains quiet on the spot when a slit opens dorso-longitudinally. The head with the entennæ comes out first, the body is then jerked slowly from side to side until the nymph is completely out of the exuvium, which remains attached to the leaf. The nymph remains

aerating on the spot close to the exuvium for a few minutes, or moves immediately in search of a suitable spot to feed. At the time of moulting the rostrum is so firmly embedded in the tissues of the leaves or the stems, that if the exuvia are lifted with a teaser the rostral setæ break away and remain in the leaf-tissues. From the eggs laid on the 21st October, 1916, an adult male emerged on the 13th November, and an adult female emerged on the 15th of the same month.

The Adult.

After passing through five moults the adults appear on the leaves and are then represented by two distinct species. The characteristic differences between the two species have been already pointed out on page 215. Of the two species, *Nephotettix bipunctatus* was the most predominant, but in habits and other respects there is no appreciable difference between the two species. The observations made and facts regarding life-history recorded in this memoir relate exclusively to *Nephotettix bipunctatus* which was found to be the predominant species in the worst infested areas of the Central Provinces during 1914 and 1915. The adults of both the species suck the juice of the leaves which wither in consequence and the plants in the infested fields appear pale, sickly and wither away prematurely without putting forth ears. The adults exude honey-dew in small, clear drops which accumulate on the lower leaves and it is on such leaves that the black fungus grows most luxuriantly. The adults of both species exhibit a strong predilection for light and it is for this reason that thousands of them are attracted to small lights (locally known as *chirags*) put out on the *Devali* day, a Hindu festival which comes off towards the end of October, or the beginning of November every year. Only a few adults survive the winter and these remain hidden in small, succulent grasses or rice stubbles growing either in damp places or in beds of shallow ponds which are very common in the affected districts of Raipur, Bilaspur and Drug in the Central Provinces and Sambhalpur in Bihar and Orissa. As soon as the winter is over they begin to breed in grasses and stubbles of plants and remain there until rice seedlings are available in June and July. Thereafter their development depends very much upon the rainfall. If it is heavy, as is usually the case in the affected districts, the majority of the adults perish and only a small proportion is left to breed either in grasses or the rice seedlings. If, however, there is a long break in the rains in July–August, the hoppers develop fast and overrun the rice crop. The female begins to lay eggs nine to ten days after reaching the adult stage. Though the number of cycles throughout the year has not been worked out, yet from observations made in the infested districts and other data available, it is presumed that there are

not more than four to five broods throughout the year. But from economic considerations, the third brood seems to be the most important, and if at the time the adults of this brood are breeding in grasses the climatic conditions become favourable, rapid development takes place and the crop is affected seriously, and to me it appears reasonable that the preventive measures should be adopted vigorously at this time. The co-operation of the *malguzars* as well as the landholders and the cultivators should be secured at this time, and I am sure, the results would yield satisfactory results.

Life-cycle.

In the latter part of the year, especially September and October, a complete life-cycle occupies from 17 to 25 days thus :—

Eggs laid	Eggs hatched	Adults emerged	Life-cycle in days
3. IX. 16	7. IX. 16	20. IX. 16	17
19-20. IX. 16	24-26. IX. 16	7-13. X. 16	18-23
19-20. IX. 16	24. IX. 16	7-13. X. 16	18-23
21. X. 16	25. X. 16	13-15. XI. 16	23-25

The egg stage lasts from 4 to 6 days, and the nymphal stage from 13 to 21 days. The adult female after reaching maturity begins laying eggs on the 9th or the 10th day. In a specific case kept under observation it was found that a female which matured on 12th October, 1916, began laying eggs on 21st October. Thereafter she survived for two days more and then died. This refers to a case under observation in a breeding cage and it is presumed that similar conditions prevail in nature also.

From the beginning of July 1915 until the middle of November 1916, grass lands, field embankments, tank bunds, river sides, etc., were bagged and examined and light traps were put up from time to time to ascertain the presence of the *Maho* and the results were as follows :—

July 1915—			
,,	2nd	Light trap	Many adult *Mahos*[1] at light.
,,	14th	Light trap	Many adult *Mahos* at light.
,,	20th	Examination of rice seedlings.	Adults on rice seedlings, majority being males.
,,	27th	Aladdin light (500 candle power).	Many adults came to light.

[1] By the term 'Maho' so frequently referred to hereafter both the species *Nephotettix bipunctatus* and *Nephotettix apicalis* are meant.

August 1915—				
,, 9th	Light trap	*Mahos* especially abundant at light ♂♂ more than ♀♀.		There was rain with cloudy weather.
,, 11th	Light trap	*Mahos* especially abundant.		
October 1915—				
,, 7th	Light trap	Many *Mahos* at light.		
,, 29th	Meduse lamp	62 *Mahos* in the trap.		
November 1915—				
,, 3rd	Grasses bagged	22 ♂♂, 14 ♀♀ *Mahos*.		
,, 18th	Examination of Paddy fields.	Eggs of *Maho* were found laid in the edges of sheathing leaves.		
,, 30th	Meduse lamp	13 ♂♂, 14 ♀♀ *Maho*.		The lamp was set up in rice-fields which were harvested only recently.
December 1915—				
,, 6th	Meduse lamp	No *Maho* was found.		
,, 9th	Aladdin lamp	No *Maho* at light.		
,, 17th	Aladdin lamp	1 ♀ at light.		
,, 21st	Meduse lamp	No *Maho* at light.		
January 1916—				
,, 12th	Grasses bagged	No *Maho* was found.		A few *Tettigoniella rubromaculata* were found.
,, 22nd	Examination of grasses.	No *Maho* was found.	2 *Thomsoniella albomaculata*. 3 *Clovia bipuncta*. 3 *Thomsoniella porrecta*.	Adults of these were found in grasses.
,, 29th	Grasses bagged	No *Maho* was found.	1 *Thomsoniella albomaculata*. 1 *Athysanus fusconervosus*. 1 *Oliarus*, sp. 3 *Tettigoniella*, sp. 1 Jassid.	Adults of these were found in grasses.
February 1916—				
,, 5th	Grasses bagged, (especially Dub grass *Cynodon dactylon*).	No *Maho* was found.	1 *Tettigoniella spectra*. 2 *Thomsoniella albomaculata*. 2 *Athysanus fusconervosus*.	These were found in grasses in the adult stages.
,, 12th	Grasses bagged	No *Maho* was found.	The adults of the following were however found : 2 *Clovia bipuncta*. 1 *Thomsoniella albomaculata*. 2 *Athysanus fusconervosus*. 1 *Adult Fulgorid*.	
,, 19th	Grasses bagged	No *Maho* was found.		
,, 21st	Aladdin lamp (500 candle power).	Many adult *Mahos* were found on the screen put behind the lamp.		
,, 26th	Green grass bagged (with handnets).	No *Maho* was found.		
March 1916—				
,, 3rd	Grasses bagged	No *Maho* was found, though the following specimens were found : 1 *Pyrilla perpusilla*. 5 *Athysanus fusconervosus*. 2 Jassidæ.		This time waste lands and fields which were last under rice were bagged with handnets.
,, 11th	Meduse lamp	No *Maho* was found.		The lamp was set up on a tank embankment close to the area under rice last season.

March 1916—			
,, 16th	Grasses bagged	No *Maho* was found, though the following were found : 1 *Eublemma*, sp. 2 *Thomsoniella albomaculata.* 1 *Tettigoniella spectra.* 1 Jassid.	
,, 25th	Grasses bagged	No *Maho* was found, the following were, however, found. 7 *Thomsoniella albomaculata.* 2 *Clovia puncta.* 1 *Tettigoniella spectra.* 2 *Tettigoniella*, sp.	
,, 28th	Meduse lamp	No *Maho* was found, though 2 *Thomsoniella albomaculata* were seen in the kerosine film.	The lamp was set up on a tank embankment close to the area under rice last season.
April 1916—			
,, 7th	Meduse lamp	No *Maho* was found.	The lamp was set up in the area under rice last season.
,, 26th	Meduse lamp	No *Maho* was found, though a large number of Jassidæ were found in the film of kerosine in the pan.	Do.
May 1916-			
,, 6th	Grasses bagged	No *Maho* was found, though the following were found: 2 *Athysanus fusconervosus* 2 *Tettigoniella spectra.* 1 Fulgorid.	Waste, as well as arable lands, were worked with handnets.
,, 13th	Meduse lamp	No *Maho* was found.	The lamp was set up by the side of the Gandak river where long grasses were growing profusely.
,, 20th	Grasses bagged	No *Maho* was found.	
,, 31st	Meduse lamp	No *Maho* was found.	The lamp was set up in waste lands full of grasses.
June 1916—			
,, 17th	Grasses bagged	3 Female *Nephotettix bipunctatus* were found.	
July 1916—			
,, 4th	Meduse lamp	2 ♀♀, 2 ♂♂ *Nephotettix bipunctatus* were found	
,, 24th	Meduse lamp	10 Adult *Nephotettix bipunctatus* and *N. apicalis* were found at light.	
August 1916—			
,, 4th	Meduse lamp	61 Adult *N. bipunctatus* and *N. apicalis* were found at light.	
,, 8th	Meduse lamp	... ...	Heavy rain at night.
,, 9th	Meduse lamp	Only 17 adult *N. bipunctatus* and *N. apicalis* were found.	
September 1916—			
,, 5th	Meduse lamp	97 ♂♂, 104 ♀♀ of *N. bipunctatus* and *N. apicalis* were found.	
15th	Meduse lamp	34 ♀♀, 44 ♂♂ of *Maho* (both the species) were found.	

October 1916—				
,,	13th	Meduse lamp	96 ♀♀ 76 ♂♂ *Mahos* (both the species) were found.	
November 1918—				
,,	3rd	Meduse lamp	16 ♀♀, 20 ♂♂ *Mahos* of both the species were found.	
,,	13th	Meduse lamp	1 ♀, 1 ♂ *Mahos* were found.	The lamp was set in rice area.
,,	17th	Meduse lamp	4 ♀♀, 10 ♂♂ *Mahos* of both the species were found.	The lamp was set in the centre of a large rice area.

The above is a record for sixteen and a half months at Pusa where the climatic and agricultural conditions are different from those prevailing in the rice tracts of the Central Provinces. Had similar observations been available from the above tract it would have been found that the adult hibernates during the winter, that it has a strong predilection for powerful light and that it begins to appear in some numbers from the latter part of June. Steady development seems to take place from the beginning of September and to last until the end of October, and this synchronizes with the development of late or transplanted varieties of paddy. The last two outbreaks bear this out. At both the outbreaks, the greatest amount of damage was done during September–October. Heavy and continuous rain seemed to exercise a prejudicial effect on the development of the hoppers. If the adults and nymphs are not actually washed off in numbers by the rain, their development is restricted considerably and little or no damage is done, as has been the case during the past three years 1916–1918. But this is a factor which cannot be depended upon to check the pest. All that can be done is to adopt preventive measures as early as possible so as to prevent the pests from laying a heavy toll on the agricultural produce as they did during 1914 and 1915.

Distribution of the pests.

Distant has recorded the two species[1] in the *Fauna of India* volumes (Rhynchota, Vol. IV, pp. 359-362) from Calcutta, Pusa, Ranchi, Saraghat, Dacca, Ceylon, Borneo, Sumatra, Philippines, East Africa, Natal and Durban. Dr. Matsumura has recorded *Nephotettix apicalis* to occur in China, Japan, Malay and Europe (*Die Schädlichen und Nutzlichen Insekten vom Zuckerrohr Formosas* 1910, p. 21).

[1] From an economic point of view the two species *Nephotettix bipunctatus* and *Nephotettix apicalis* have been considered together as in development and habits they are much the same.

In the Pusa collection specimens are from :—

Bihar and Orissa	...	**Pusa, Balasore, Chhapra, Kankey Farm (Ranchi), Sambhalpur.**
Bengal	...	**Calcutta, Dacca, Chaumahani.**
Central Provinces	...	**Raipur District, Sakti, Janjgir (Bilaspur District), Drug District, Sindewahi (Chanda District).**
South India	...	**Coimbatore, Penukonda, Hagari. Throughout the Plains generally.**
Assam	...	**Aijal-Champhai (Lushai Hills).**

The greatest damage was done in parts of the Central Provinces and Bihar and Orissa. In the Central Provinces, Bilaspur District and some parts of the Raipur District were the worst affected tracts. In Bihar and Orissa considerable damage was done in the Balasore and Cuttack districts. In the Sambhalpur District, the pest was reported for the first time in 1910. Subsequently a report was received from the Superintendent, Lushai Hills, in 1913 that one of the hoppers *Nephotettix apicalis* had damaged the rice crop considerably. From no other part of the country have the pests been reported to have damaged the rice crop to any serious extent. If, however, careful and continued observations are made in the rice-growing tracts, the hoppers will be found to be present though only in small numbers.

Alternative foodplants.

Hitherto the hoppers have been known to affect the paddy plants only, though they are also found in a number of succulent grasses growing in the beds of rivers, nallahs, tank beds and low-lying places. In February 1915 when I visited Sakti State, Bilaspur District, only a few adults were found by me in the long grasses growing in dry beds of ponds and tender rice-plants growing from stubbles of the previous crop. Besides these, the hoppers have not been observed up to this time, infesting or feeding in numbers on any other crop, though it appears probable that in cases of future serious outbreaks they might affect the millets as well. In the Central Provinces they have been found on *Kodon* (*Setaria italica*) and a number of grasses though in very small numbers.

Varieties of paddy affected.

The early ripening varieties *Harhuna* and *Parewa* do not suffer so much as the *Gurmatias*[1] late ripening varieties. The grain in the ears, as well as the leaves of the former varieties, become too tough and matured to attract the hoppers which appear late in the season. It was for this reason that little

[1] **Local names of varieties of rice in the Chhatisgarh Division, Central Provinces.**

or no damage was done to the early ripening varieties in 1915, as the pests appeared late in numbers. Such varieties are usually sown early and ripen by the middle of October and are then past damage. The late varieties, which are mostly transplanted and, wherever possible, irrigated, remain green and succulent and offer an attractive breeding place for the hoppers. During years of serious infestation an inquiry was begun to find the degree of immunity enjoyed by the local varieties, as it was then thought expedient to recommend extension of an early ripening variety or varieties to escape the loss caused by the hoppers. In fact, in certain parts of the Bilaspur District in the Central Provinces, some of the intelligent cultivators, fearing probable loss of their crop by the hoppers, had put down a greater portion of the acreage cultivated by them under early ripening varieties, which, though coarse, find an easy sale in the local markets in the district. But as the hoppers have not appeared for the last three years, the inquiry has not advanced much further.

From an extensive examination of the affected areas it was also noticed that varieties of paddy growing in *Gehunras*[1] lands were more infested by the hoppers than the same varieties growing in *Matasi*[2] and *Bhata*[3] lands, and the explanation given by me then seems to hold good even now. It was then pointed out by me thus (Report on Investigations regarding the "Maho" *Nephotettix bipunctatus* and *N. apicalis* in the Central Provinces—October 1915, C. S. Misra) :—

"The reason for the preponderance of the pest in one kind of soil than the other is, according to my ideas, explained by the fact that, the *Gehunras* lands being enriched with the washings from the village, produce more succulent plants than those growing in *Matasi* and *Bhata* lands. The plants in the *Gehunras* lands were beautiful deep pale-green, those in the *Bhata* lands being pale-yellow. The ears too of plants in *Gehunras* fields were more filled with grain than those of the *Bhata* lands. Thus, finding the plants in *Gehunras* lands to be more succulent than those in the *Bhata* lands, the pests concentrated themselves in such areas in large numbers. Besides this, the feeding habits of the pests warrant some such conclusion. It being a sucking insect prefers to remain on green, succulent plants than on pale-yellow, prematurely ripening plants. This conclusion I could arrive at after examining a number of fields at Janjgir (Bilaspur District, Central Provinces) sown with *Harhun* and *Gurmatia* varieties of rice in *Gehunras, Matasi* and *Bhata* lands."

[1] Lands adjoining villages which are manured from washings from such villages and droppings of cattle which graze therein.

[2] Clay-loam soils.

[3] High-lying lands with calcareous nodules in them.

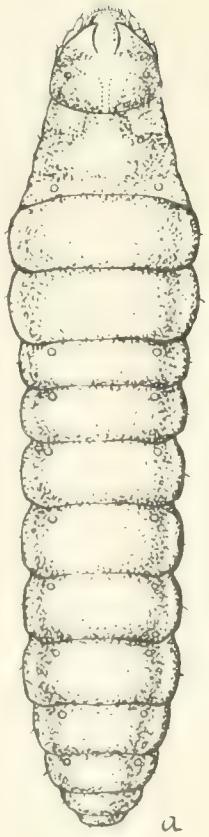
Local names of the pests.

In the Raipur and the Bilaspur districts of the Central Provinces the pests are known as *Mahor* or *Maho*, most commonly the latter. They are so called because they cause the blight of the paddy crop. In the adjoining Orya District of Sambhalpur, they are known as *Daoni*, *Ghunghutti* or *Dhana*. The Lushais call them the *Kumthu*. In the Balasore District (Bihar & Orissa) the pests are known as *Jhatka*. Elsewhere the local names of the two hoppers are not known.

Other Insects which either precede or occur concurrently with the hoppers.

Prior to the appearance of the leaf-hoppers, a number of other insects are found in numbers on the paddy plants. Of these *Heiroglyphus banian* Fb., locally known as the *Phapha*, and three species of the Delphacid leaf-hoppers, *Sogata pusana* Dist., *Sogata distincta* Dist., and *Sogata pallescens* Dist. (Figs. 1, 2 and 3), are the most important. In fact the three Delphacid leaf-hoppers preceded the *Maho* in the Chhattisgarh Division, Central Provinces and appeared by the end of July 1915 when they were mistaken for the *Maho*. The damage brought about by them is very much like the *Maho*, but they are dirty-white in colour and *are not attracted to light*. In fact, they appeared in such large numbers that it was feared that the paddy crop would be damaged seriously, and the climatic conditions prevailing at the time of their appearance favoured this view. Damp moist weather seemed to favour their development whilst a break in the rains seemed to affect them prejudicially. With the break in the rains and the continuance of hot sunny days the Delphacid leaf-hoppers perished and were not heard of again. The work of destruction was to some extent hastened by the timely appearance of the Dryinid parasite (Plate XXI, fig. *c*).

At the end of September 1915 innumerable Delphacid hopper nymphs with chestnut-brown to blackish bags of the Dryinid parasite were seen protruding from the anal or metapleural region laterally (Fig. 5). With the presence of these bags, the nymphs became sluggish in their movements and succumbed ultimately to a premature death. Besides these, a large number of whitish, hammock-like cocoons of the Dryinid parasite were to be met with commonly on the leaves of plants in the infested fields. At this time the adult Dryinids were to be seen in large numbers flitting about the infested fields. Invariably the nymphs were the chief victims. In no case could I see the adults parasitized. When full-fed, the chestnut-brown metapleural



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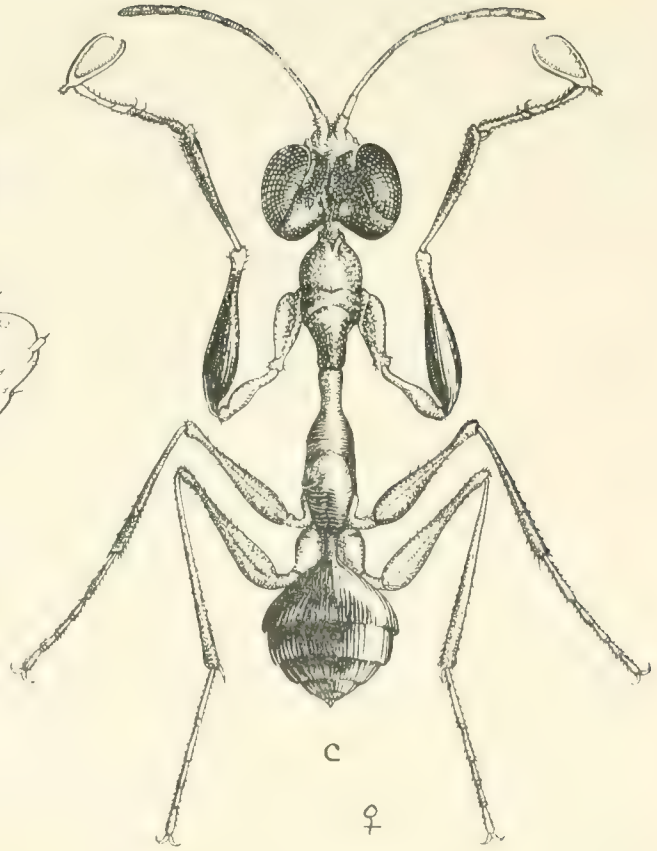

c

♀

DRYINID PARASITE ON *SOGATA* SPP.

a , Larva X 33.

b , mouthparts of larva, highly magnified.

c , adult, female, magnified.

PLATE XXI.

or anal sacs enclosing the nymphs within dehisce longitudinally, and whitish grubs come out (Plate XXI, fig. *a*). These move about but little, and spin a whitish hammock-like cocoon enclosing within it another cocoon of a thicker texture. On emergence the adult female Dryinid (Plate XXI, fig. *c*) ærates its limbs for some time, the antennæ being moved from side to side very rapidly. It then flies away with a dart, pounces upon an unwary nymph of the Delphacid-hopper, catches hold of it in its anterior legs and within the twinkling of the eye oviposits into it. The parasitized nymph lies prostrate for some time, until it is able to move about slowly on the leaf. With the appearance of the sac laterally or at the anal end, the nymph becomes slow in its movements and is not able to jump about actively. When the sac, enclosing the Dryinid grub within it dehisces, the parasitized nymph dies with its legs spread out wide apart.

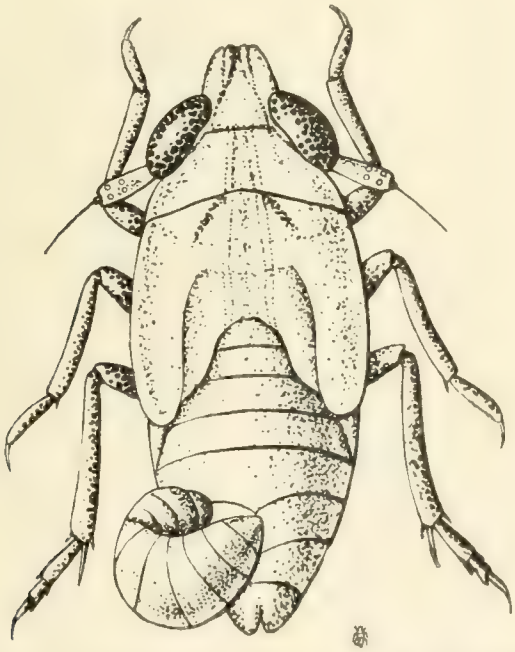

FIG. 5. Nymph of *Sogata* Sp. with Dryinid larva on its anal extremity (× 30).

The Delphacid leaf-hoppers, *Sogata pusana* Dist., *Sogata distincta* Dist., *Sogata pallescens* Dist. (Figs. 1, 2 and 3), oviposit in the tissues of the leaves. The females lacerate the tissues with their strong ovipositor longitudinally and deposit in them small whitish eggs. The colour of the eggs when laid freshly is pale-white, these deepen into dark-grey when fully matured with

two prominent spot representing the eyes of the nymph within. The nymph on hatching moves about the leaf until it comes upon a suitable succulent place to feed. It then thrusts in its rostrum and continues to suck the sap which would have otherwise gone to the maintenance of the plant. All this

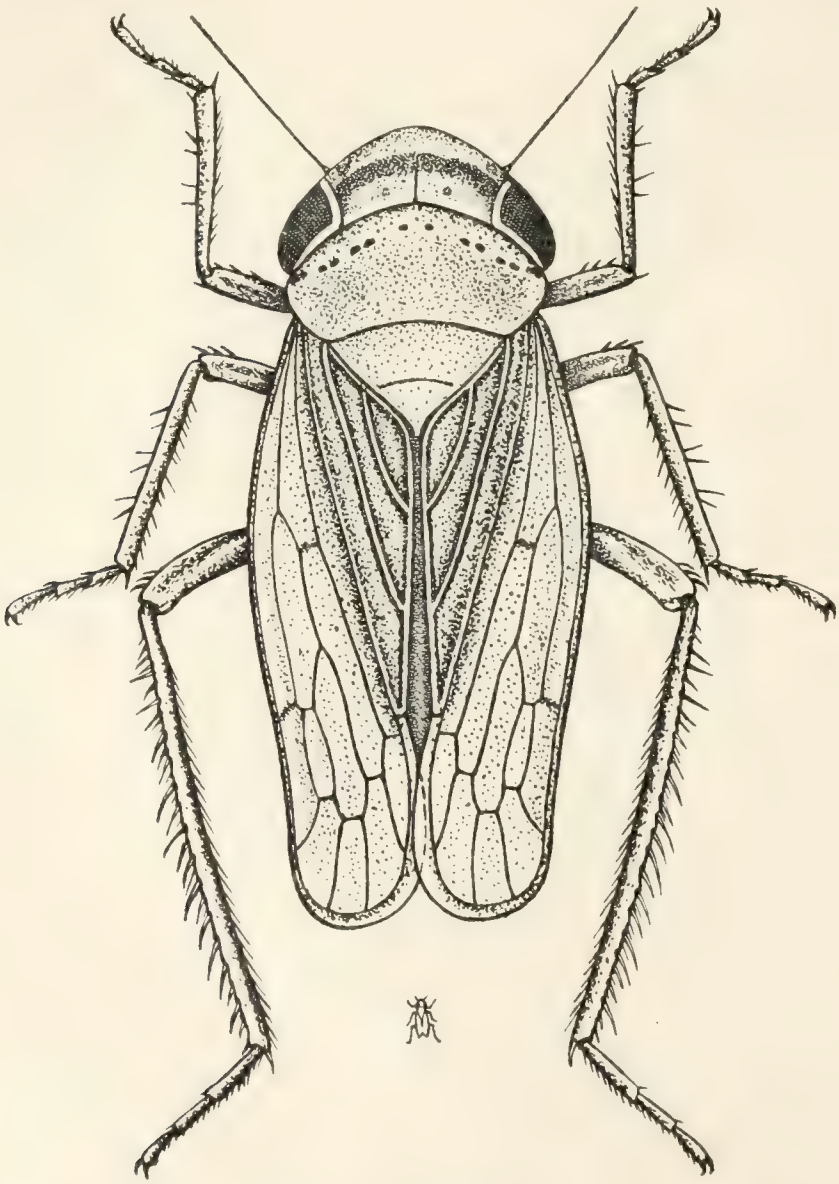

FIG. 6. *Athysanus indicus* (× 27).

time, it too, like the nymphs of the rice leaf-hoppers, *Nephotettix bipunctatus* and *N. apicalis*, exudes honey-dew in small, clear droplets which falling on the lower leaves form a thick matrix for the growth of the black fungus, *Capnodium* sp. The nymphs are very active and with the least jerk or disturbance jump off from leaf to leaf. The moults are passed on the leaves and the exuvia may be seen lying thickly on the infested leaves. The adults too are very active, but are not attracted to light. It was a species of this genus that appeared in enormous numbers in the Burdwan Division in Bengal in 1907, and devastated practically the whole of the paddy crop in that division.

Besides these, two species of *Oliarus* are also found on the paddy plants along with the following leaf-hoppers.

1. *Athysanus indicus* Dist.

[*Fauna of India,* Vol. IV, pp. 344-345.]

This hopper occurs mostly in green grasses on field-embankments, but with the least disturbance jumps off and settles on the paddy plants in the field. It is somewhat smaller than *Athysanus fusconervosus,* but can be distinguished readily from the latter by the presence of an arcuate impressed line near the anterior margin of the pronotum on which there are more or less distinct brownish or piceous spots (Fig. 6).

2. *Athysanus fusconervosus* Motsch.

[*Fauna of India,* Rhynchota IV, p. 344, Fig. 219].

This is a greyish-ochraceous leaf-hopper with a black curved transverse fascia between the eyes. The adult may be seen on the plants along with the two species of the rice leaf-hoppers.

3. *Thomsoniella albomaculata* Dist.

[*Fauna of India,* Rhynchota IV, p. 280, Fig. 179].

This is a pale or greenish-ochraceous leaf-hopper (Fig. 7) which is seen on the paddy plants, as well as the green, succulent grasses on the boundaries of fields along with *Thomsoniella porrecta* Walk. [*Fauna of India,* Rhynchota IV, p. 278, Fig. 178] and *Thomsoniella* sp.

4. *Tettigoniella spectra* Dist.

[*Fauna of India,* Rhynchota IV, p. 211, Fig. 137].

In some parts of the Bilaspur District, especially in the Sakti State this pale flavous leaf-hopper was very abundant with two other species of *Tettigoniella.* The adult hoppers were to be seen in large numbers on the leaves and the stems of the paddy plants, as well as the green grasses on field-embankments. The female lays eggs in a longitudinal line in the leaves sheathing stems and the nymphs that hatch out remain feeding on the leaves.

In some instances the eggs were found parasitized by a very small, pale-yellow Chalcidid. The parasitized eggs turn dark-grey in colour and when the adult parasite has emerged there is a round hole in the egg-shell.

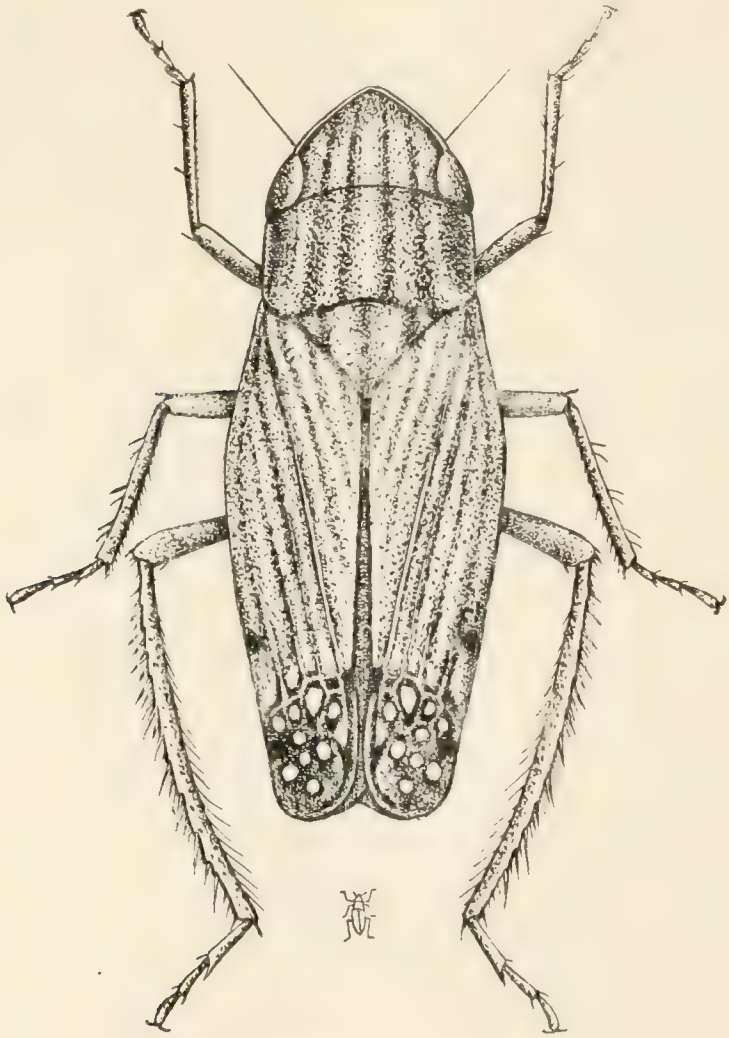

FIG. 7.] *Thomsoniella albomaculata* (20).

5. *Kolla* sp.

[*Fauna of India*, Rhynchota IV, p. 223].

This leaf-hopper superficially resembles *Tettigoniella spectra* found in large numbers on the paddy plants as well as the grasses, its habits and

PACHYDIPLOSIS ORYZÆ.

Explanation of Plate XXII.

Fig. 1, a cluster of rice plants several of which are affected

Fig. 2, an affected plant, with the pupa in its natural position exposed.

Fig. 3, egg enlarged.

Fig. 4, full-grown maggot.

Figs. 5 to 7, different views of pupa.

Figs. 8 and 9, the adult fly in sitting and flying attitudes.

The small outline figures indicate natural sizes.

Explanation of Plate XXII

Fig. 1. A specimen of [illegible] natural [illegible] size.

Fig. 2. [illegible] [illegible] [illegible] [illegible]

Fig. 3. [illegible]

Fig. 4. [illegible]

Figs. 5 to 7, [illegible]

Figs. 8 and 9. The [illegible]

The small oblong figure [illegible]

development are very much like the rice leaf-hoppers with which it is likely to be confused. The adult female deposits the eggs in the tissues of the leaves as well as the stems, and the places oviposited present an oval swelling if examined very carefully with a handlens. The number of these hoppers was not very large, and it was rather difficult, if not impossible, to distinguish them in the fields from *Tettigoniella spectra*.

6. *Selenocephalus virescens* Dist.

[*Fauna of India*, Rhynchota IV, p. 291].

This has been reported to occur in large numbers along with *Nephotettix apicalis* at Champhai in the Lushai Hills. In the lot of specimens received for identification it was found that the number of these was fairly large and it is possible that on some future occasion, provided the climatic and other conditions are favourable to its development and rapid multiplication, it might take the place of *N. bipunctatus* and run concurrently with *N. apicalis* in the particular region referred to above.

7. *Paramesus lineaticollis* Dist.

[*Fauna of India*, Rhynchota IV, p. 294, Fig. 186].

8. *Clovia puncta* Walk.

[*Fauna of India*, Rhynchota IV, p. 94].

A small, pale, tawny-brown Cercopid leaf-hopper with a black spot at posterior angle of inner margin of tegmina. The adult hoppers were to be seen in larger numbers in the green grasses on field-embankments rather than on the paddy plants. On account of its colour and compact appearance it can be distinguished readily from other leaf-hoppers (Fig. 8).

In the Cuttack and the Balasore districts in the Province of Bihar and Orissa, the rice stem-fly, *Pachidiplosis oryzalis* W. Mason, occurred at about the same time as the two rice leaf-hoppers were running their course (Plate XXII, fig. 8). The affected plants turn pale-green in appearance, and the stems become elongate and converted into hollow tubes with small leaflets on the top. The diseased plants become stunted in growth and do not produce ears filled with grain. In some villages the damage done by the Cecidomyiad fly was very great indeed, but in others there were affected patches scattered all over the rice area. The flies were very prominent during August-September, but their number diminished by the middle of October. Locally, the disease is known as *Thenga* (meaning 'a rod') and is so called on account of the characteristic malformation of the stems. On cutting open and examining the affected stems, I invariably found the pupæ of the fly. A few adults

were also seen by me in the infested fields, but the number was not very large.

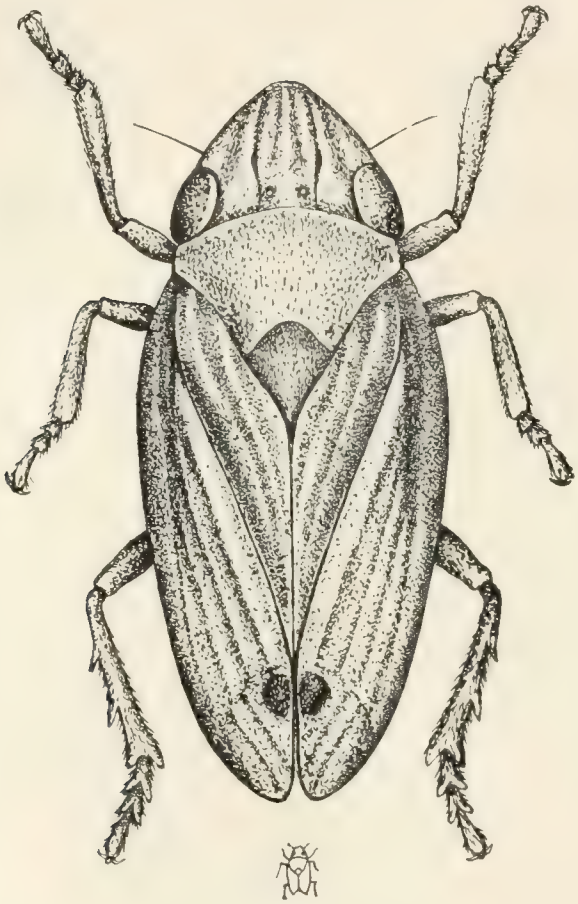

FIG. 8. *Clovia puncta.* (× 13).

Besides these, *Schœnobius bipunctifer*, *Cnaphalocrosis medinalis* and *Chapra mathias* were also present in some numbers in paddy fields affected by the leaf-hoppers.

PARASITES AND PREDATORS.

The number of parasites and predators hitherto observed on the leaf-hoppers is not very large. The eggs are parasitized by a small, pale-yellow Chalcidid (Fig. 9). The parasitized eggs turn black and the adult parasites emerge by making clean, circular holes on the egg-shell which remain embedded in the tissues of the sheathing leaves. Such parasitized eggs were found by

me at Janjgir in the Bilaspur District, as well as at Pusa, but the parasites could, in no sense, be said to be an effective check to the development of the

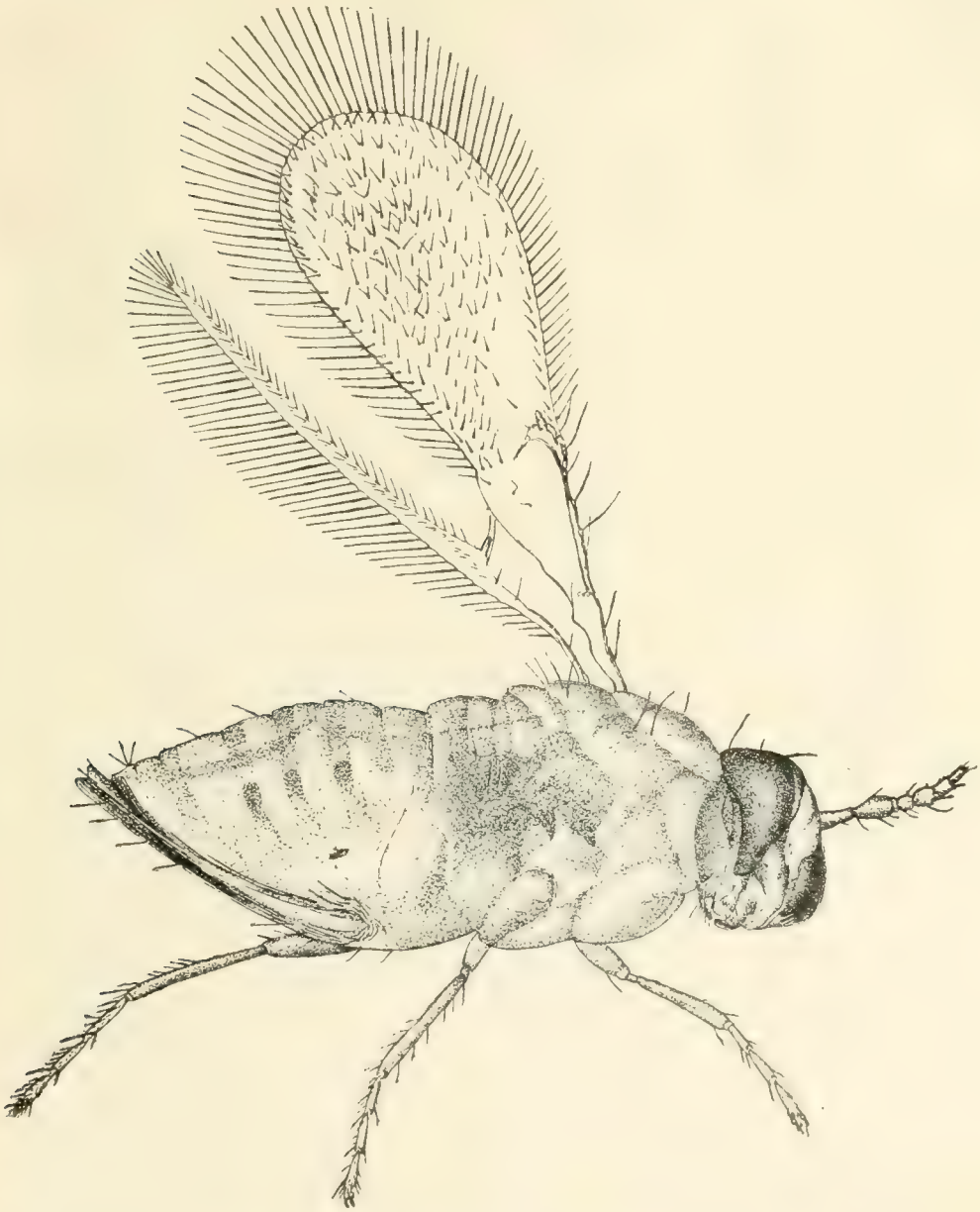

FIG. 9. Chalcid parasitic on eggs of *Nephotettix bipunctatus* and *N. apicalis* (× 150).

leaf-hoppers as the percentage of parasitized eggs was extremely small. Besides these, the nymphs of the leaf-hoppers were found by me at Janjgir in the Bilaspur District to have blackish bags of a Dryinid protruding from their meso—as well as metapleural regions, but all my attempts to rear out the adult parasites were not successful. The number of such parasitized nymphs was very small and the few that were collected were obtained after a long and weary search. Besides Janjgir, no such parasitized nymphs were found by me in other hopper-infested areas in the Sambhalpur and the Balasore districts in Bihar and Orissa. In a village in the Bilaspur District, a number of egg-masses were found infested by a small pale-yellow mite which found its way in through a small hole on the egg-masses. It could not, however, be ascertained definitely whether the mites entered before or they found their way in after the parasites had emerged, but it was certain that the mite-infested egg-masses turned deep brown in colour and failed to hatch in proper time. In fact, all attempts to find an effective parasite which would keep down the pests proved abortive. As is usually the case, in cases of serious and sudden outbreaks of pests, like the present ones, a small percentage of parasitized eggs as well as nymphs, is to be met with, but the question from an economic point was whether these parasites could be counted upon to check the hoppers to any appreciable extent. That such was not the case was borne out from a number of observations made to this effect in a number of places in the worst infested areas. In short, no such parasites and predators were noticed during the years that the hoppers were under observations which could be said to have kept them in check effectively.

Measures tried.

From the life-history of the hoppers given above (pages 213–219) it will be seen that the only vulnerable point in the life-cycle of the pests is their strong predilection for light. To take advantage of this, the adoption of lantern traps was recommended on a large scale. But owing to the prevalence of the war, when every thing was very dear, the right kind of oil could not be obtained locally to be used in the lanterns. All that was available was a very low grade of petroleum, which when used in the lamps smoked badly and darkened the glass to such an extent that they were practically useless. In normal times, this would not have been the case, as kerosine oil of good quality could be obtained readily. Besides this, to obtain the best results it was necessary that the cultivators of a tract should have co-operated to destroy the pests, but the Chhattisgarhi cultivator is very superstitious and lethargic. No amount of persuasion could induce him to go to his fields in the night and lit

up the lamps, as he is mortally afraid of evil spirits, which, he thinks, hover over the fields at night. Had the measure only been adopted on a large scale in proper time, the results would have been very satisfactory. In some places the lamps were used when the hoppers were only in the nymphal stages, and as such could not be expected to come to light. In others, the lamps were set up in the fields in the months of July and August when altogether different insects, the Delphacid Leaf-hoppers (*Sogata* spp.), were present in enormous numbers on the plants. But as these insects are not attracted to light, the lamps could not be said to have served their purpose. To get optimum result by the use of lantern traps it is first necessary to determine, whether the *Mahos* are actually present in the fields or it is some other insect or insects which have preceded them. If this discrimination is not made, time, money and energy employed in the use of lantern traps on a large scale over a wide area are likely to yield no substantial results. Before putting out the lantern traps it is necessary to have the crops examined by an entomologist and then to adopt measures suited to the local conditions.

Besides the lantern traps the following measures were also tried :—

1. Torches or *mashals* made from material obtained locally, were set up at the corners of infested fields in *Gchunras* areas (lands adjoining villages). But from observations conducted on a number of days it was found that these were not effective, as few *Mahos* were attracted to them.

2. Bonfires were lit up either on the embankment of fields or other prominences in the vicinity of rice areas, and it was found that these were not effective and as such were given up.

3. Kerosine oil was squirted on the surface of the water of the infested fields and a rope was passed over to dip the plants in the water. But it was found that in large fields the rope sagged in the middle and in consequence the plants at the sides did not bend sufficiently to come in contact with the water. If the fields were large, a man was told to hold the rope in the middle and to walk slowly in the middle. In small fields, the rope passed well over the plants but the hoppers jumped off to other plants and thus escaped destruction. In adopting the measure on a large scale, it was necessary to obtain labour locally, but this was not obtainable readily.

4. Bagging the infested fields with field-bags. It was found that a bag 4 ft. long attached to a light bamboo frame 6 ft. long by 4 ft. broad worked well (Plate XXIII, fig. 1). Prior to working it, kerosine oil was squirted in the interior either with a syringe or a sprayer. The bag was worked at a walking pace and against the direction of the wind. If, however, it became a calm or the wind stopped suddenly while the bags were at work, the cloth sagged and fell heavily

on the plants which broke off from the middle. In some places, the cultivators were induced to sprinkle kerosine oil on their *dhotis* and to work them in the *Maho*-infested fields against the direction of the wind. It was found that 4 men working a bag alternately could bag an area of 6 acres in 10 hours. The bag described above could be made locally for Rs. 2 to Rs. 2-4, but now, as the price of the cloth has gone up, it will cost a little more.

Measures recommended for adoption.

The pests have not been reported since 1915, but as they are sporadic serious pests, it is necessary to adopt such preventive measures as may prevent their recurrence. The causes which have brought about this change are not well understood at present, and the observations recorded in this Memoir represent two years' work in the infested tracts in the Chhattisgarh Division of the Central Provinces. But so far as is known, it is certain that the climatic conditions play no mean part in the development and subsequent multiplication of the pests. If, however, there are good rains after the paddy crop has been harvested, and in consequence the stubbles in the fields tiller well, it is possible that the pests, finding abundant food-plants, might reproduce quickly, and if there are no heavy rains in August–September but a spell of hot sunny days, there is every possibility of the pests damaging the crop to some extent. What this would approximately be, nobody can foretell. It would then be advisable to adopt the following measures :—

(1) To impress upon the local cultivators the absolute necessity of clean cultivation, to allow no grassy-lands to remain in the immediate vicinity of rice-areas.

(2) To impress upon the local cultivators the necessity of allowing cattle to graze freely in the harvested areas, as well as in the dry beds of ponds and streams where grasses grow luxuriantly.

(3) To bag the nurseries with hand-nets or *dhotis* previously moistened with kerosine oil.

(4) To bag the areas in July–August if there is a break in the rains and if the days are hot and sunny. The bagging should be done preferably with large field-bags 6 ft. long, 4 ft. broad with a cloth-bag 4 ft. deep attached to a light bamboo-frame (Plate XXIII. fig. 1). The bags should be worked at a walking pace and against the direction of the wind. The inside of the bags should be moistened with kerosine to prevent the hoppers, when once they have got in, from getting out. The contents of the bags should be emptied in vessels containing water and a little kerosine on top of it. In case there is much water in the fields, it is better to drain them and to attach the cloth-bag to two upright

Fig. 1. Field-Bag (Type A) to be used when the paddy plants are small.

Fig. 2. Field-Bag (Type B) to be used when there is much water in the fields.

bamboo poles 4 ft. long. This prevents the plants from breaking off with the impact of the cross-bamboo poles of the bag (Plate XXIII, fig. 2).

(5) Kerosine oil should be squirted on the surface of fields containing sufficient water in them and a rope should be drawn across them by two men so as to shake the plants. By doing so the nymphs as well as the adults come in contact with the kerosine and are destroyed.

(6) To set up lantern-traps during July–August when the adults are about and there is a break in the rains with hot, sunny days. As the adults have a strong predilection for light they will be attracted to the light-traps and will be destroyed. Thus the future generations will be restricted considerably and even if damage be done it will be slight only. Before setting up lantern traps it should be determined, as accurately as possible, whether the *Maho* or some other insect is actually present. If the latter are present and if the lantern-traps are set up, no good would accrue as it would not be possible to ascertain for certain if these too have a predilection for the light. Bagging and setting up of lantern-traps, if adopted at proper times, are expected to yield very satisfactory results; whether this is so or not, future outbreaks would only show.

Besides these, if the pests again break out hereafter and run consecutively for a series of years, it would then be worth considering the question of selection of such varieties of paddy as are wholly or partially immune from the attacks of the hoppers. The question of early-ripening varieties will have to be considered also and it is a fact, that the cultivators in the worst infested tracts in the Chhattisgarh Division of the Central Provinces, after their said experience for two years, actually sowed early-ripening varieties over a large area during 1915 and 1916.

Summary.

The rice leaf-hoppers were first heard from Sambhalpur, Bihar and Orissa, in 1910, as specific pests of rice, and four years later they were reported to have damaged 300,000 acres, causing a loss approximately of fourteen million rupees in the Chhattisgarh Division only of the Central Provinces. At the instance of the Director of Agriculture, Central Provinces, observations were begun and measures were tried during 1914 and 1915 and these are incorporated in this Memoir. The pests have not been reported from the Chhattisgarh Division, Central Provinces, since 1916 and it is presumed that the prompt adoption of measures early in 1915, prevented the pests from establishing themselves in the infested area.

ACKNOWLEDGMENTS.

Considerable help was received from the Department of Agriculture, Central Provinces, and I have to thank Mr. D. Clouston, M.A., Offg. Director of Agriculture, Central Provinces, for allowing me the services of the Agricultural Inspectors at a time when the situation was very grave. I have also received considerable help from G. D. Ojha, Fieldman to the Imperial Entomologist, Pusa.

June 1919.

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